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Bulletin No. 54 - Cattle Feeding

Luther Foster

Lewis A. Merrill

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CATTLE FEEDING

I.—A COMPARISON OF UTAH FEEDING STUFFS.

II.—DIGESTION EXPERIMENTS WITH SHREDDED CORN-FODDER, LUCERN, TIMOTHY AND WHEAT-BRAN.

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CATTLE FEEDING.

I.—A COMPARISON OF UTAH FEEDING STUFFS.

LUTHER FOSTER. LEWIS A. MERRILL.

PREVIOUS WORK.

For three successive seasons, just preceding the work herein detailed, experiments had been conducted at this Station for the purpose of determining the comparative yield and feeding value of early, medium and late cut lucern, also of the first, second and third crops, the object being to decide, by chemical tests and feeding trials, at just what period of its growth lucern should be cut for the best results, and, pound per pound, the relative value of the different crops.

In Utah, where the chief dependence for coarse forage is lucern, this work is of great practical importance and would have been continued during the winter of 1896-7 had the Station come under its present management in time to arrange for the proper cuttings of the different crops of lucern. Finding it thus necessary to defer this special line of investigations until another season, our attention was directed to other equally valuable problems in cattle feeding for the State.

UTAH CATTLE FOODS.

While lucern is the principal coarse fodder used in beef production, timothy hay and mixed hay are not infrequently resorted to, and corn fodder is occasionally fed. Of the concentrated foods, bran and shorts are usually the cheapest and perhaps the most generally used, though barley, oats and rejected wheat are, in some instances, fed in connection with them, especially during the last half of the feeding period to give the animals a better finish for the market. In a large portion of the State not enough attention has been given to corn growing to prove its efficiency for cattle feeding in connection with our two most common stock foods, lucern and bran.

One of the principal objects of the experiment was to widen

somewhat the resources of the feeder by showing, if possible, that other foods, aside from those usually resorted to, viz.: lucern, timothy, bran and shorts, could be made profitable use of in beef production. Not only this but a better balanced ration could be thus secured, enabling the farmer to make more economical use of his accustomed foods, at the same time giving a more completely finished product. In feeding characteristics, corn and lucern are complementary, the former being rich in fat, starch and sugar—the compounds essential for heat, energy and the laying on of fatty tissue—while the latter is abundantly supplied with protein, the part absolutely necessary for the making of muscle and bone as well as the general machinery of the system.

Bran and shorts, like lucern, are rich in protein, and for best results not only in securing a well balanced ration but also in making the most economical use of our feeding stuffs, should be fed in combination with some forage strong in the opposite elements—carbohydrates and fat—as corn fodder, timothy or mixed hay.

OUTLINE OF EXPERIMENT.

With these various animal foods and their characteristic nutrients in mind, the following experiment was planned:

Lot 1 was fed lucern alone during the first period, and a grain ration of barley was added for the second period.

Lot 2 was fed lucern and straw, with a grain ration of barley and bran during both periods.

Lot 3 was fed corn fodder during the first period, with a ration of bran added the second.

Lot 4 was fed on timothy hay alone the first period, a ration of bran and pea meal, half and half by weight, being added during the second.

Lot 5 was fed lucern and shredded corn fodder, half and half during the first period, with the addition of a bran and barley ration the second.

Lot 6 was fed shredded corn fodder and roots the first period, bran being added the second.

All of the above lots were fed in the barn.

Lot 7 was a duplicate of lot 2, fed in an open yard.

Lot 8 was a duplicate of lot 3, fed in an open yard.

Lot 9 was fed lucern in an open yard, with a grain ration during both periods, barley and bran being given for the first period and barley alone the second.

FEEDING PERIODS.

This experiment was in progress from January 1 to March 31, 1897, making a total of 90 days, which time was divided into two periods of 39 and 51 days respectively. During the first of these periods, with a few exceptions, the coarse fodders were given alone, partly to compare their feeding value as single forage crops unaffected by the balancing force of a grain ration, and partly to determine the digestibility of the different fodders with the fewest possible complications, also to learn what benefits, if any, result from giving a grain ration with lucern during the preliminary feeding period.

DIVISION INTO LOTS.

All of the lots, except No. 6, contained four steers each, and this had only two. The number of animals in each division of a feeding experiment is of much importance. The individual variation is too great to put much reliance in the results from a single animal. In steer feeding the number should not, as a rule, be less than three, to secure a reliable average, and other things being equal, the greater the number of animals in each lot of a feeding experiment, the greater the reliance that may be placed in the average result.

The division into sets was made not only by weight, but the size and general characteristics of the steers were also considered, great care being exercised to make the lots as nearly even in all respects as possible.

WEIGHING.

The steers were weighed three days in succession at the beginning and at the close of the experiment, the average of the first three being taken as the beginning weights, and of the last three as the closing weights of the experiment. Throughout both periods of feeding, the weighing was done regularly every Monday after the morning feed had been eaten, and before watering, all weights being taken separately.

CONDITIONS.

Lots 1 to 6, inclusive, were tied in the barn where the temperature very seldom went down to the freezing point. They were turned into an open yard daily for water and exercise. During pleasant weather they remained outside five hours; at other times only long enough to drink. Lots 7, 8 and 9 were kept in yards with open sheds that they could run into at their pleasure.

THE RECORD.

A complete and accurate history of an experiment is one of its most essential features. Much more should be shown on the record than ever appears in the report of the work, every detail being necessary to a full interpretation of the results. The feeders' sheets, tacked to the bulletin board in the barn, were each arranged to hold one month's record of the daily ration fed to each lot. The total amounts of both hay and grain as well as the waste, each carefully weighed, were here recorded, together with any other facts affecting the experiment. These daily notations, with the weekly weights of the steers, were regularly transferred to the permanent record book of feeding experiments. In addition to the above, here, also, was kept a careful record of all outside matters relating, in any way, to the work.

KIND OF STEERS.

The thirty-four steers used in this experiment were purchased from farmers in the Cache Valley. With a few exceptions they were 2-year-olds past, and were a fairly representative bunch of such as farmers generally feed. In breed they were principally grade Shorthorns and Devons, with a few Aberdeen Angus and Holsteins, but few of them showed very strongly marked characteristics of the breed they represented. All were home-bred, the greater portion being what is familiarly known as "buttermilk steers," having been raised on the product of the dairy. They had been sent to the range in summer and returned to the farm and fed during the winter. As a result of such handling they were fairly gentle, not showing special resistance when tied in their stalls, nor any nervousness afterwards, though, as compared with the open yard sets, a small loss in weight did result from their sudden change of condition—from the freedom of the corral to the confinement of the barn.

PRELIMINARY WORK.

In order to familiarize them with their new conditions they were tied in their respective stalls December 22d, and from that time on given the same ration they were to receive during the experiment. They were turned into the feeding corrals about two weeks prior to this; and, up to the time of tying in the barn, were given a half ration of lucern, and all the corn stover they would eat. With the exception of a steer or two off-feed for a

few days there was nothing occurred to detract, in any way, from the reliability of the experiment.

SHREDDED CORN FODDER.

The corn fodder used in this experiment was cut and put into shocks when the grain was well glazed. It was thoroughly cured and in excellent condition when shredded and stored in the barn. The St. Albans shredder, used for this work, made perfect corn-hay of the fodder, tearing the stalks into fine shreds, breaking the cobs into small pieces and shelling and distributing the corn very evenly through the whole mass.

The proportion of shelled corn in the fodder was accurately determined by weighing and separating samples just as taken to feed. The average of these results gave 34 per cent, showing that in the usual daily ration of corn fodder, 20 pounds, the steer received nearly 7 pounds of shelled corn. The fodder shredded was of different varieties of flint corn, though dents of the small, early maturing kinds, succeed equally well on the Station grounds.

This work shows that in our dry atmosphere, corn fodder may be so thoroughly field cured that there is no danger of heating when shredded and stored where it is protected from the weather.

The following yields for the past six years, taken from the Station records, show that in the matter of the certainty of the crop, as well as the quantity of food produced per acre, corn may be safely reckoned as one of the feeder's resources in Utah:

CORN YIELDS.

Thick and Thin Planting Test.

	BU.
Average of all plantings, 1892	76.63
" " " 1893	29.69
" " " 1894	56.56
" " " 1895	56.75
" " " 1896	66.56
" " " 1897	35.85
Average for six years	53.67

CORN CULTURE INVESTIGATIONS.

Average for 1894, 12 plats	60.88
" " 1895, "	65
" " 1896, "	72.69
" " 1897, "	69.11
Average for four years, 12 plats	66.92

OTHER FEEDING STUFFS.

The lucern used in the experiment was purchased from farmers in the neighborhood of Logan, at prices ranging from $2.50 to $4.00 per ton in the stack. It was mostly of the first crop, and was a fair average in quality of what is usually fed in the valley.

The timothy hay was of very good quality, and as nearly pure as could be obtained, though it had a little red top mixed through it.

The straw was of good quality. It was a general mixture of wheat and oat, though the wheat straw largely predominated. It had received no damage from rain, having been stored in the barn mow at threshing, soon after harvest.

What is termed bran in the outline and tables, was the mill run of both bran and shorts, the two products not having been separated. The miller estimates 400 pounds of shorts to every 1000 pounds of bran, thus making the product only a little more than 70 per cent of bran. The 30 per cent of shorts makes the food a little more valuable, because of its greater digestibility. The average results of many digestion experiments show that there are 53.8 pounds digestible in every 100 pounds of bran to 66.8 in every 100 pounds of shorts. By reference to the second part of this bulletin, it will be noticed that the digestibility of the mixed product, bran and shorts, used in the experiment, was found by Prof. Widtsoe to be 52.6 pounds per 100, showing under the special conditions of the experiment a result not quite as high as the general average.

THE GRAIN RATION.

At the beginning of the second period when grain was added to the coarse forage, the whole ration was made to approach Wolff's standard for the main feeding period as nearly as the foods at our command would permit. From the tables it will be seen that, to the coarse forage rich in protein, the grain containing the most carbohydrates and fat was added, and to that largely composed of carbohydrates and fat, a grain ration was given rich in protein. Of the concentrated foods at hand, barley was found the best to feed with lucern, bran with shredded corn fodder, and with timothy bran and pea meal. It was found necessary to add a part ration of pea meal, a food exceedingly rich in protein, to properly balance a coarse ration of timothy hay, which is very deficient in this nutrient. Where

two coarse foods, complementary in composition, were given, the grain ration was similarly constituted; for example, with a ration consisting of half and half lucern and corn fodder, the grain added was one-half each, by weight, of bran and barley. The peas and barley were ground into coarse meal, and these, as well as the bran, fed dry. It was the intention to feed all the steers would eat, regulating the coarse forage partly by the amount and character of the waste which was accurately weighed and carefully examined every day, and the grain by the amount needed to properly balance the ration.

THE TABLES.

Table I shows the weights, gains and losses of the different lots for each week, each separate period, and for the whole time of feeding. It also shows the average gain per day, per steer, for the first and second periods, and for the entire time.

In Table II, the total number of pounds of the different oods fed, eaten and required for one pound of gain, the total gains and the rate of gain per head daily, are given in addition to some important data relative to the quantity of digestible dry matter consumed. This table, taken with the preceding, shows very completely the work and results of the experiment. From a careful study of the two, many deductions may be made. Attention is called here only to the more important.

It will be seen that the lots 2, 7 and 9, which had the grain ration, made much more rapid gains during the first period than any lot without grain, though these were not, in all instances, the most profitable gains. The gain on lot 1 was made not only at a less cost per pound than on lot 2, but the whole profit was also greater. The ration of lot 2 for the period was principally lucern and grain since only 194 pounds of straw was eaten, making the comparison, with this exception, a fair one. Comparing lot 1 with 9, the economical growth is still more strongly marked in favor of lot 1, lucern without grain, the gain being made at a cost of more than one cent per pound less than that of lot 9. These results indicate that there is no profit obtained from feeding grain with lucern during the preliminary period, though the effect on the after feeding may be sufficiently important to warrant its addition. Such a conclusion, however, could not be drawn from the continuation of this experiment. The second period shows a falling off in rate of gain for all lots fed grain the first period, as well as for the set on lucern alone.

The lowest gain for the period was made by lot 6, on corn fodder and roots. Comparing this with lot 3 on corn fodder, and remembering that lot 6 contained only two steers, it will be seen that there was apparently a saving of 130 pounds of corn fodder per head, at the cost of 271 pounds of roots, and that there was a loss of .88 pounds in daily rate of gain, resulting from the substitution of roots for a part of the corn fodder ration. Continuing the comparison for the second period after the grain ration had been added to both sets, and the results are more favorable to roots. The amount of corn fodder and bran eaten by the two sets did not differ materially, and the extra gain of 47 pounds made by lot 6 may be attributed to the 600 pounds of roots eaten. But taking the whole feeding period, there was smaller gain per head on the root lot, notwithstanding the fact that it ate per head 571 pounds of roots, in addition to 120 pounds of corn fodder and 35 pounds of bran more than the other lot. The report of the results of a similar experiment in Bulletin No. 17 shows that roots compared with dry foods made better gains, but at greater cost per pound. It also shows that 16 pounds of mangels given per head daily, made a saving in mixed hay and corn fodder of only 8.6 pounds. Still another experiment in which carrots were used, detailed in the Fourth Annual Report, shows that the rate of gain was not only lower for roots than for dry fodder, but that the steers in the root set consumed, in addition to the carrots, more coarse forage and grain than those fed only on dry foods. These three trials imply that for the amount of dry matter they contain, roots are less profitable than the ordinary fodders; but it is possible that a small ration, given for their effect as a stomach regulator, rather than for the nutrients they contain, would result profitably. None of the experiments reported included this phase of the question.

STRAW WITH LUCERN.

Previous experiments had been conducted in determining the value of straw as a part ration in connection with lucern, the two foods being complementary to each other in their feeding constituents, the lucern having an undue proportion of protein, and the straw of carbohydrates. In continuation of this work, and to determine what effect outside feeding has on the extra consumption of this heat-producing food, and if such conditions are more conducive to its profitable use than inside

TABLE 1.—First Period, January 1 to February 8, Thirty-nine Days.
Weights, Gains and Losses of Steers in Pounds, First Period 1896-7.

1896-7	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9
FOOD GIVEN	Lucern.	Lucern, Straw and Grain.	Corn Fodder (Shredded).	Timothy.	Lucern and Corn Fodder.	Corn Fodder and Roots.	Lucern, Straw and Grain.	Corn Fodder.	Lucern and Grain.
Average weight, January 1, 2 and 3	3457	3376	3440	3361	3538	1792	3378	3460	3330
Weight, January 11	3660	3498	3522	3501	3586	1818	3460	3499	3480
Gain or loss	203	122	82	140	48	26	82	39	150
Weight, January 18	3717	3560	3560	3554	3684	1790	3510	3458	3529
Gain or loss	57	62	38	53	98	—28	50	—41	49
Weight, January 25	3686	3630	3640	3499	3698	1809	3581	3567	3510
Gain or loss	—31	70	80	—55	14	19	71	109	—19
Weight, February 1	3738	3657	3560	3518	3736	1778	3628	3526	3618
Gain or loss	52	27	—80	19	38	—31	47	—41	108
Weight, February 8	3720	3715	3650	3566	3754	1828	3690	3576	3669
Gain or loss	—18	58	90	48	18	50	62	50	51
Total gain during period	263	339	210	205	216	36	312	116	339
Gain pr day, pr steer, dur. period	1.69	2.17	1.34	1.31	1.39	.46	2.00	.74	2.17

Second Period, February 8 to March 31, Fifty-one Days.
Weights, Gains and Losses of Steers in Pounds, Second Period 1896-7.

FOOD GIVEN	Lucern and Grain.	Lucern, Straw and Grain.	Corn Fodder and Grain	Timothy and Grain.	Lucern, Corn Fodder and Grain.	Corn Fodder Roots and Grain.	Lucern Straw and Grain.	Corn Fodder and Grain.	Lucern and Grain.
Weight, February 8	3720	3715	3650	3566	3754	1828	3690	3576	3669
Weight, February 15	3686	3711	3620	3513	3726	1812	3721	3586	3680
Gain or loss	—34	—4	—30	—53	—28	—16	31	10	11
Weight, February 22	3706	3770	3698	3528	3796	1900	3754	3652	3758
Gain or loss	20	59	78	15	70	88	33	66	78
Weight, March 1	3808	3851	3794	3582	3824	1898	3860	3814	3912
Gain or loss	102	81	96	54	28	—2	106	162	154
Weight, March 8	3776	3825	3820	3596	3819	1901	3911	3917	3918
Gain or loss	—32	—26	26	14	— 5	3	51	103	6
Weight, March 15	3942	3904	3913	3692	3956	1988	3958	4004	4024
Gain or loss	166	79	93	96	137	87	47	87	106
Weight, March 22	3960	3943	3976	3768	3976	2026	3992	4056	4026
Gain or loss	18	39	63	76	20	38	34	52	2
Average weight, March 29, 30 and 31	3951	3946	3972	3766	3983	2036	4065	4131	4068
Gain or loss	—9	3	—4	—2	7	10	73	75	42
Total gain during period	231	231	322	200	229	208	375	555	399
Gain pr day, pr steer, dur. period	1.13	1.13	1.58	.98	1.12	2.04	1.84	2.72	1.96

Whole Period, Ninety Days.
Weights, Gains and Losses of Steers in Pounds, 1896-7.

FOOD GIVEN	Lucern and Grain.	Lucern, Straw and Grain.	Corn Fodder and Grain.	Timothy and Grain.	Lucern, Corn Fodder and Grain.	Corn Fodder, Sugar Beets and Grain.	Lucern, Straw and Grain	Corn Fodder and Grain.	Lucern and Grain.
Average weight, Dec. 22, 23 and 24	3505	3465	3480	3459	3602	1793	3264	3424	3296
Weight, December 28	3336	3370	4406	3338	3562	1767	3260	3512	3264
Average weight, January 1, 2 and 3	3457	3376	3440	3361	3538	1792	3378	3460	3330
Average weight, March 29, 30 and 31	3951	3946	3972	3766	3983	2036	4065	4131	4068
Total gain	494	570	532	405	445	244	687	671	738
Gain per steer, per day, during whole period	1.37	1.58	1.48	1.12½	1.24	1.35½	1.91	1.86	2.05

TABLE No. II.

Weights of Feed and Gains of Steers, First Period, 39 Days.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9
	Lucern.	Lucern, Straw, Grain.	Corn Fodder.	Timothy.	Lucern, Corn-fodder.	Corn-Fodder, Roots.	Lucern, Straw, Grain.	Corn-fodder.	Lucern, Grain.
Average Weight Jan 1st, 2d and 3d	3457	3376	3440	3361	3538	1792	3378	3460	3330
Weight, February 8th	3720	3715	3650	3566	3754	1828	3690	3576	3669
Total gain during the period	263	339	210	205	216	36	312	116	339
Average gain per day, per steer	1.69	2.17	1.34	1.31	1.39	.46	2.00	.74	2.17
Total lucern fed	3294	1900	....	....	1486	....	1896	....	2922
" " eaten	3080	1875	....	....	1405	....	1876	....	2701
" " wasted	214	25	....	....	81	....	20	....	221
" straw fed	....	387	....	....	....	....	712	....	....
" " eaten	....	194	....	....	....	....	525	....	....
" " wasted	....	193	....	....	....	....	187	....	....
" corn fodder fed	....	....	2797	....	1486	1189	....	3069	....
" " " eaten	....	....	2451	....	1330	967	....	2731	....
" " " wasted	....	....	346	....	156	222	....	338	....
" timothy fed	....	....	....	2621	....	....	....	....	....
" " eaten	....	....	....	2415	....	....	....	....	....
" " wasted	....	....	....	206	....	....	....	....	....
" barley eaten	....	455	....	....	....	....	458	....	458
" bran eaten	....	471	....	....	....	....	471	....	471
" roots eaten	....	....	....	....	....	543	....	....	....
Food eaten per day, per steer	19.74	19.19	15.71	15.48	17.53	19.36	21.41	17.51	23.21
Total pounds of digestible dry matter in coarse fodder, eaten	1616.69	1064.	1280.89	1215.23	1432.54	505.35	1200.69	1427.22	1417.75
Total pounds of digestible dry matter in grain and roots eaten	....	560.48	....	....	....	100.18	614.78	....	614.78
Total pounds of digestible dry matter eaten.	1616.69	1624.48	1280.89	1215.23	1432.54	605.53	1815.47	1427.22	2032.53
Pounds of digestible dry matter for one pound of gain	6.15	4.79	6.09	5.92	6.63	16.82	5.84	12.30	5.99
Pounds of food eaten for one pound of gain — coarse fodder	11.71	6.10	11.67	11.78	12.66	25 15	7.69	23.56	7.96
Pounds of food eaten for one pound of gain — grain	....	2.73	....	....	....	....	2.98	....	2.74

Roots not taken into account in last statement of table.

TABLE No. II—CONTINUED.

Weights of Feed and Gains of Steers, Second Period, 1896-97—51 days.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9
	Lucern, Grain.	Lucern, Straw, Grain.	Corn-fodder, Grain	Timothy, Grain.	Lucern, Corn-fodder, Grain.	Corn-fodder, Roots, Grain.	Lucern, Straw, Grain.	Corn-fodder. Grain.	Lucern, Grain.
Weight, February 8th	3720	3715	3650	3566	3754	1828	3690	3576	3669
Average Weight, March 29th, 30th, 31st	3951	3946	3972	3766	3983	2036	4065	4131	4069
Total gain during period	231	231	322	200	229	208	375	555	400
Average gain per day per steer	1.13	1.13	1.58	.98	1.12	204	1.84	2.72	1.96
Total lucern fed	3928	2939	....	....	1778	....	2951	....	3902
" " eaten	3534	2722	....	....	1520	....	2790	....	3536
" " wasted	394	217	....	....	258	....	161	...	366
" straw fed	....	447	....	....	....	...	970	....	....
" " eaten	....	273	....	....	....	....	729	....	...
" " wasted	....	174	....	....	....	....	241	....	....
" corn-fodder fed	....	....	3359	....	1754	1771	....	4148	....
" " " eaten	....	....	2745	...	1558	1392	....	3597	...
" " " wasted	....	....	614	...	196	379	...	551	....
" timothy fed	....	....	....	3336	....	....	....	....	....
" " eaten	....	....	....	3002	....	....	....	....	....
" " wasted	....	....	....	334	....	....	....	....	...
" barley eaten	1207	809	....	...	648	....	810	....	1830
" bran eaten	....	794	1227	723	669	683	794	1341	126
" roots eaten	....	....	....	pea meal 420	....	600	....	....	....
Food eaten per day per steer	22.34	22.54	19.47	20.32	21.54	26.21	25.10	24.40	26.92
Total pounds of digestible dry matter in coarse fodder eaten	1855	1541.08	1434.54	1510.61	1612.06	727.46	1763.86	1879.79	1856.04
Total pounds of digestible dry matter in grain and roots eaten	945.80	1065.31	666.08	686.38	868.11	851.76	1065.10	728.56	1502.44
Total pounds of digestible dry matter eaten	2800.80	2606.39	2100.62	2196.99	2480.17	1579.22	2828.96	2608.35	3358.48
Pounds of digestible dry matter for one of gain	12.12	11.29	6.52	10.98	10.83	7.59	7.54	4.69	8.02
Pounds of food eaten for one pound of gain { coarse fodder	15.3	12.97	8.52	15.00	13.44	6.69	9.38	6.48	8.84
Pounds of food eaten for one pound of gain { grain	5.23	6.94	3.81	5.71	5.75	3.28	4.28	2.42	4.89

TABLE NO. II—CONTINUED.

Weights of Feed and Gains of Steers, Whole Period, 1896-97—90 Days.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9
	Lucern, Grain.	Lucern, Straw, Grain.	Corn Fodder, Grain.	Timothy, Grain.	Lucern, Corn Fodder, Grain.	Corn Fodder, Roots, Grain.	Lucern, Straw, Grain.	Corn Fodder, Grain.	Lucern, Grain.
Average weight, Jan. 1, 2, 3..	3457	3376	3440	3361	3538	1792	3378	3460	3330
" " March 29, 30, 31	3951	3946	3972	3766	3983	2036	4065	4131	4068
Total gain during period	494	570	532	405	445	244	687	671	738
Average gain per day per steer	1.37	1.58	1.48	1.13	1.24	1.36	1.91	1.86	2.05
Total lucern fed	7222	4839	....	....	3264	....	4847	....	6824
" " eaten	6614	4597	....	....	2925	....	4666	....	6237
" " waste	608	242	....	....	339	....	181	....	587
" timothy fed	....	....	....	5957	....	....	....	....	....
" " eaten	....	....	....	5417	....	....	....	....	....
" " waste	....	....	....	540	....	....	....	....	....
" straw fed	....	834	....	....	....	....	1682	....	.....
" " eaten	....	467	....	....	....	....	1254	....	....
" " waste	....	367	....	....	....	....	428	....	....
" corn fodder fed	....	....	6156	....	3240	2960	....	7217	....
" " " eaten	....	....	5196	....	2888	2359	....	6328	....
" " " waste	....	....	960	....	352	601	....	889	....
" grain eaten	1207	2529	1227	1143	1317	683	2533	1341	2885
" roots eaten	....	....	....	....	....	1143	....	....	....
" food eaten per day per steer	21.72½	21.09	17.84	18.22	19.81	23.25	23.48	21.30	25.34
Total pounds of digestible dry matter in coarse fodder eaten	3471.69	2605.08	2715.43	2725.83	3044.6	1232.81	2965.07	3307	3273.79
Total pounds of digestible dry matter in grain and roots eaten	945.80	1625.79	666.08	686.38	868.11	951.94	1680.87	728.56	2117.22
Total pounds of digestible dry matter eaten.	4417.49	4230.87	3381.51	3412.21	3912.71	2184.75	4645.94	4035.56	5391.01
Pounds of digestible dry matter for 1 pound of gain	8.94	7.42	6.36	8.43	8.79	8.96	6.76	6.01	7.29
Pounds of food eaten for one pound of gain. { coarse fodder	13.39	8.88	9.76	13.37	13.06	9.67	8.62	9.43	8.44
{ grain	2.44	4.44	2.31	2.82	2.96	2.79	3.69	2.00	3.90

No waste grain or roots.

Roots not taken into account in last statement of table.

feeding, three sets of steers were selected and fed as follows: Two outside lots were taken to determine if any advantage results from a part straw ration. One was given a full ration of lucern with grain, the other a limited amount of lucern and all the straw that would be eaten, together with a grain ration. An inside set was also given a part straw ration, and in all respects, except the housing, made a duplicate of the outside set. These lots are represented in the tables as Nos. 2, 7 and 9. It will be seen in comparing the two outside lots, 7 and 9, that the lucern lot made the higher rate of gain, but taking the lucern fed, it required 2.18 pounds more for a pound of gain than for the lucern-straw lot. At this rate, the whole gain on lot 7 was made at a saving of 1498 pounds of lucern, an amount almost equal to the quantity of straw fed, showing that for a certain portion of the ration, straw was almost equal in value to lucern. There was also a saving of 158 pounds in the amount of grain eaten.

The real test, however, is the cost of production. From this point of view, the gain of lot 9 cost 3.8 cents per pound, and lot 7, 3.25 cents, a difference of .55 cents per pound in favor of lot 7, making a saving of $3.77 by the use of 1682 pounds of straw. The results of two seasons' experiments, reported by Prof. Mills in Bulletin No. 44, agree with those given above, all indicating that straw may be fed with lucern to advantage. The following table gives a brief summary of the three seasons' work. Comparing the inside and outside lots 2 and 7, table II, the amount of lucern and grain eaten differs very little, but the open air lot ate 1254 pounds of straw to the inside lot's 467 pounds. As a result of the extra food eaten, 48 pounds of grain, 67 pounds of lucern and 787 pounds of straw, the outside set gained during the whole period 117 pounds more than the inside. Counting this gain at the selling price, 3½ cents per pound, and deducting the cost of the extra lucern and grain, there remains $3.93 as compensation for the extra straw eaten by the outdoor lot.

OUTSIDE VS. INSIDE FEEDING.

The results of inside as compared with open yard feeding depend much upon climatic conditions and the kind of steers. In general, mild, dry winters, similar to the average of Utah, and range cattle are favorable to outside feeding, while cold, stormy winters, or those subject to sudden changes and

TABLE III.

Weights of Food and Gains of Steers.

1896-7. Full Period, January 1 to March 31—(90 Days).	Lucern and Grain lbs.	Lucern, Straw and Grain lbs.
Average weight, January 1, 2 and 3	3,330	3,378
Average weight, March 29, 30 and 31	4,068	4,065
Total gain during period	738	687
Average gain per day, per steer	2.05	1.91
Total lucern fed	6,824	4,847
Total lucern eaten	6,237	4,666
Total lucern waste	587	181
Total straw fed	.....	1,682
Total straw eaten	.....	1,254
Total straw waste	.....	428
Total grain eaten	2,885	2,533
Total food eaten per day, per steer	25.34	23.48
Total fed	9,709	9,062
Food required for 1 pound of gain	13.16	13.19

1894-5. Full Period December 29 to May 1—(123 Days)—Fed Grain.	Lucern	Lucern and Straw
Average weight, December 27, 28 and 29	3,692	3,681
Average weight, April 29, 30 and May 1	4,656	4,713
Total gain during period	964	1,032
Total gain per day, per steer, from December 29 to May 1	1.96	2.09
Total hay fed	8,683	7,034
Total straw fed	.....	1,060
Total bran fed	2,134	2,134
Total wheat fed	1,982	1,982
Total fed	12,799	12,210
Waste	494	495
Total eaten	12,305	11,715
Food eaten per day, per steer	25	23.79
Food required for one pound of gain	13.28	11.83

1895-6. Full Period, December 5 to April 22—(139 Days).		
Average weight, December 3, 4 and 5	1,839	1,855
Average weight, April 20, 21 and 22	2,329	2,575
Total gain during period	490	720
Gain per day, per steer	1.76	2.59

frequent rains and home bred steers offer conditions favorable to stall feeding.

Below are given in tabular form the results of last winter's work, and also of a previous experiment reported in Bulletin No. 11. All of the outside sets made much better gains than any of the inside sets, though the only lots that admit of exact comparison are Nos. 2 and 3 with 7 and 8; no other inside and

outside lots having been given exactly the same ration during both periods. The outside sets frequented the sheds in stormy weather, and always lay down in them at night. This shelter is a building 28 feet square, boarded up on all sides, with a shingle roof, the inside being separated into four divisions, one for each yard, by tight board partitions 4½ feet high. Four doorways 3x6½ feet, two on the north and two on the south, open into the yards giving free admission to air currents—though the prevailing wind is from the Logan Canyon, directly east of the buildings. The outside conditions, freedom and exercise, gave better appetites, as shown by the extra straw and corn fodder eaten. They also aided in more complete assimilation of the food, enabling the steers to make better use of it, as shown by the higher rates of gain and the greater quantity of food required for a pound of gain inside than out. The trials reported above, and others made under different conditions, all indicate that in this climate with the kinds of steers that are fed, the best results are obtained by giving the animals the freedom of a corral, and a warm building which they may occupy at will.

TABLE IV.—OUTSIDE AND INSIDE FEEDING.

Weights of Feed and Gains of Steers

1896-7. Whole Period (90 Days).	Lot 2 Inside	Lot 7 Outside	Lot 3 Inside	Lot 8 Outside
	Lucern, Straw and Grain.	Lucern. Straw and Grain.	Corn Fodder and Grain.	Corn Fodder and Grain.
Average weight, January 1, 2 and 3	3,376	3,378	3,440	3,460
Average weight, March 29, 30 and 31	3,946	4,065	3,972	4,131
Total gain during period	570	607	532	671
Average gain per day, per steer	1.58	1.91	1.48	1.86
Total lucern fed	4,839	4,847		
Total lucern eaten	4,597	4,666		
Total lucern waste	242	181		
Total straw fed	834	1,682		
Total straw eaten	467	1,254		
Total straw waste	367	428		
Total corn fodder fed			6,156	7,217
Total corn fodder eaten			5,196	6,328
Total corn fodder waste			960	889
Total grain eaten	2,529	2,533	1,227	1,341
Total food eaten per day, per steer	21.09	23.48	17.84	21.30
Total fed	8,202	9,062	7,383	8,558
Total food required for one pound of gain	14.39	13.19	13.88	12.75

January 16 to March 2, 1892. Whole Period (47 days).	Fed in Open Air	Turned Out Daily
Weight January 16	2,298	2,236
Weight March 2	2,502	2,428
Total gain during period	264	192
Total grain eaten	540	540
Total hay eaten	2,127	1,797
Total eaten	2,667	2,337
Gain per day, per steer	1.96	1.42
Total food required for one pound of gain	10.1	12.1

TIMOTHY HAY.

For the full period, timothy hay made not only the lowest, but decidedly the most unprofitable gain. This latter fact resulted partly from the higher price of the hay and partly from the use of pea meal, a more valuable food, which seemed necessary to secure more nearly the right proportion of digestible protein in the ration. The low rate of gain was, no doubt, due to the smaller per cent of digestible matter contained in timothy hay than the other coarse fodders, and also to its being less palatable, as shown by the quantity of dry matter eaten. As a single food, timothy did not prove equal to the lucern or shredded corn fodder, as an examination of the tables for the first

period will show. Such a result would naturally be anticipated from a study of the composition and digestibility of the different fodders. The nutritive ratio or proportion of digestible protein to carbo-hydrates in timothy is only one to sixteen, that of lucern being one to five and of corn fodder one to twelve. This fact accounts for the better results of the second period after the grain ration had been added, increasing the proportion of protein to more nearly the due amount. Two previous trials conducted by Prof. Mills, in which timothy was incidentally compared with clover and with the different cuttings and different crops of lucern, gave results in rate of gain much more favorable to the timothy hay, though in the cost per pound of gain they agreed fully with that reported above, showing the cost of gain to exceed very much that of other forage. In composition timothy is more suitable than lucern to feed with bran, but the per cent of digestible matter of both, and more especially of the bran, is rather low compared with grain and enough of it is not eaten to give a well-balanced ration. While the results of the different trials do not indicate that timothy is not a good crop for cattle feeding, they do show that it cannot be used for the purpose to advantage, while the prices of lucern and timothy remain relatively the same as at present.

SHREDDED CORN FODDER.

From a study of the results shown in the tables, it will be seen that the shredded corn fodder lots, both inside and outside, compared very favorably with the others in rate of gain for the entire feeding period. Of the lots in the barn the corn fodder did best of all excepting the lucern-straw set which had a grain ration during both periods. The gain was made at the least cost per pound of any inside lot. The whole gain on the lucern set cost $4.10 more than that on the corn fodder, the lucern-straw $3.48 more and the timothy $9.31 more. In the yards, both of the other sets made higher gains than the corn-fodder. This may have resulted from both of them having a grain ration during the whole time of feeding, while the shreded corn fodder was given alone the first period. However, it will be noticed that the gain of the corn-fodder set, though not quite as large as either of the others, was a more profitable one, costing one-tenth cents less, per pound than the lucern-straw set and nearly nine-tenths cents less than the lucern set.

It was expected that lucern and corn fodder being quite op-

posite in their characteristic nutrients would give excellent results when fed in combination, very much better than either fed alone. This work, taken as a whole, was rather disappointing, though for the first period the gain was greater for the combination than for the corn fodder alone. For the second period the combination ran much lower, making the average of the whole time considerably less than either the lucern or corn fodder. Compare lots 1, 3 and 5 for results.

In table 5 will be found the total pounds of dry matter, and the number of pounds of the nutrients digestible in 100 pounds of each of the foods used and also the nutritive ratios.

In table six are given the average daily consumption per head of digestible nutrients with the nutritive ratio, and the average number of pounds of digestible dry matter required for a pound of gain, for the different lots by periods and for the whole time.

Table 7 shows for the separate periods and for the whole time the total dry matter eaten by the different lots, the total nutrients digested and the nutritive ratio or the proportion of digestible protein to the digestible carbo-hydrates and fat.

TABLE V.
Digestible Nutrients in Foods.

FOOD.	Total dry matter. 100 lbs.	Total lbs. of digestible in 100 lbs.		Nutritive ratio.
		Protein.	Carbo-hydrates and Fat.	
Corn-fodder	81.36	3.90	49.14	1:12.6
Lucern	85.39	8.11	41.36	1:5.1
Timothy	86.90	2.65	46.37	1:17.5
Bran	90.28	10.71	43.91	1:4.1
Barley*	89.1	8.7	69.2	1:8.0
Pea-meal*	89.5	16.8	53.1	1:3.2
Wheat straw*	90.4	0.6	39.3	1:65.5

*From Armsby.

TABLE VI.
Pounds of Digestible Nutrients Consumed, 1st Period, 39 Days.

LOT.	Per Head per Day.			Digestible Nutrients for 1 lb. of Gain.	Nutritive ratio.
	Protein.	Carbo hydrates and Fat.	Total lbs. Gain.		
Lot 1	1.60	8.16	1.69	5.77	1:5.1
" 2	1.56	8.80	2.17	4.77	1:5.6
" 3	.61	7.72	1.34	6.22	1:12.6
" 4	.41	7.18	1.31	5.79	1:17.5
" 5	1.06	7.91	1.39	6.45	1:7.4
" 6	.59	6.85	.46	16.17	1:11.5
" 7	1.57	9.65	2.00	5.61	1:6.1
" 8	.68	8.60	.74	12.54	1:12.6
" 9	1.98	10.52	2.17	5.76	1:5.3

TABLE VI.—CONTINUED.

Digestible Nutrients Consumed—2nd Period, 51 Days.

Lot 1.....	1.92	11.26	1.13	11.66	1:5.8
" 2.....	1.86	10.38	1.13	10.83	1:5.6
" 3.....	1.17	9.25	1.58	6.59	1:7.9
" 4.....	1.11	9.47	.98	9.45	1:8.5
" 5.....	1.53	10.47	1.12	10.71	1:6.8
" 6.....	1.34	10.29	1.02	6.32	1:7.7
" 7.....	1.89	11.51	1.84	7.29	1:6.1
" 8.....	1.44	11.44	2.72	4.73	1:7.9
" 9.....	2.25	13.64	1.96	8.10	1:6.1

Digestible Nutrients Consumed During Whole Period, 90 days.

Lot 1.....	1.78	9.92	1.37	8.54	1:5.6
" 2.....	1.73	9.69	1.58	7.23	1:5.6
" 3.....	.927	8.59	1.48	6.44	1:9.3
" 4.....	.809	8.48	1.13	8.22	1:10.5
" 5.....	1.33	9.36	1.24	8.62	1:7.1
" 6.....	1.02	8.79	1.36	7.21	1:8.6
" 7.....	1.75	10.71	1.91	6.53	1:6.1
" 8.....	1.11	10.21	1.86	6.09	1:9.2
" 9.....	2.14	12.28	2.05	7.03	1:5.7

TABLE VII.

Total Nutrients Digested, 1st Period.

JANUARY 1st–FEBRUARY 8th—1897.	Total dry matter.	Total lbs. of digestible.		Nutritive ratio.
		Protein.	Carbo-hydrates and Fat.	
Lot 1, Lucern, ...In barn	2630. lbs.	249.78 lbs.	1273.89 lbs.	1:5.1
" 2, Lucern, Straw, Grain,... "	2607.06 "	243.25 "	1373.42 "	1:5.6
" 3, Corn-fodder (shredded) "	1994.13 "	95 59 "	1204.22 "	1:12.6
" 4, Timothy ..... "	2098.63 "	63.99 "	1119.84 "	1:17.5
" 5, Lucern & Corn-fodder, "	2281.82 "	165 81 "	1234.67 "	1:7.4
" 6, Corn-fodder and roots. "	860.05 "	46.40 "	534.37 "	1:11.5
" 7, Lucern. Straw, Grain, In yards	2909.81 "	245.58 "	1505.98 "	1:6.1
" 8, Corn-fodder..... "	2221.93 "	106.51 "	1342.01 "	1:12 6
" 9, Lucern, Grain..... "	3139.68 "	309.33 "	1640.89 "	1:5.3

NOTE.—Analyses of Corn-fodder, Lucern, Timothy and Bran taken from the Utah Experiment Station. Other fodders and grains taken from Armsby.

Total Nutrients Digested, 2d Period, February 9–March 31, Inclusive—1897.

Lot 1, Lucern and Grain. ... In barn	4093.12 lbs.	391.6 lbs.	2296.90 lbs.	1:5.8
" 2, Lucern Straw, Grain... "	4184.12 "	379.37 "	2117 80 "	1:5.6
" 3, Corn-fodder and Grain "	3340.60 "	238.35 "	1887.33 "	1:7.9
" 4, Timothy and Grain.... "	3637.35 "	227.54 "	1932.52 "	1:8.5
" 5, Lucern, Corn-fodder & Grain..... "	3746.98 "	311.96 "	2135.75 "	1:6.8
" 6, Corn-fodder, Roots & Grain ..... "	1829.84 "	137.02 "	1049.33 "	1:7.7
" 7, Lucern, Straw, Grain, In yards	4479.08 "	386.07 "	2349.30 "	1:6.1
" 8, Corn-fod'r and " "	4433.91 "	293.75 "	2334.43 "	1:7.9
" 9, Lucern " " "	4763.67 "	459.47 "	2782.18 "	1:6.1

Total Nutrients Digested Whole Period, January 1–March 31—1897.

Lot 1, Lucern .....In barn	6723.12 lbs	641.38 lbs.	3570.79 lbs.	1:5.6
" 2, Lucern and Straw..... "	6791.18 "	622.62 "	3491.22 "	1:5 6
" 3, Corn-fonder..... "	5334.73 "	333.94 "	3091.55 "	1:9.3
" 4, Timothy ..... "	5735.98 "	291.53 "	3052.36 "	1:10.5
" 5, Lucern & Corn-fodder.. "	6028.80 "	477.77 "	3370.42 "	1:7.1
" 6, Corn-fodder and Roots "	2689.89 "	183.42 "	1583.70 "	1:8.6
" 7, Lucern and Straw.....In yards	7388.89 "	631.65 "	3855.37 "	1:6.1
" 8, Corn-fodder ..... "	6655 84 "	400.26 "	3676.44 "	1:9.2
" 9, Lucern..... "	7903.35 "	768.80 "	4423.07 "	1:5.7

NOTE.—Sets 2, 7 and 9 received grain the first 39 days. All sets received grain the last 51 days.

The following table shows the cost per pound of gain of the different lots for the first, second, and whole periods. The market prices of the various foods were used as a basis for the estimate and were as follows: Lucern $4 per ton; shredded corn fodder, $5; timothy hay, $6; bran, $10; barley, $16; peas, $20; roots, $3.50, and straw, $1.

COST PER POUND OF GAIN, IN CENTS.

	First Period.	Sec'nd Period	Whol' Period.
Lot 1. Lucern*	2.5	7.58	4.88
" 2, Lucern and Straw	2.94	7.12	4.65
" 3. Corn-fodder	3.33	4.51	4.04
" 4, Timothy	3.83	8.91	6.34
" 5. Lucern and Corn-fodder	3.09	7.19	5.20
" 6. Corn-fodder and Roots	10.89	4.27	5.36
" 7. Lucern and Straw	3.26	4.40	3.93
" 8. Corn-fodder	6.61	3.08	3.68
" 9. Lucern	3.5	5.77	4.73

*All had grain the second period. Lots 2, 7 and 9 the first.

PROFITS.

The gain in live weight for the whole period was in no instance made at a cost as low as the selling price. Had the gains alone been considered the feeding would have been done at a loss, but the original cost of the steers at the market price for "feeders" was from one to one and one half cents per pound less than the finished product. There are two elements to be considered in calculating the profits from feeding; first, the actual gain, and second, the increased value of the whole finished product. When the prices of steers for feeding range almost as high as beef animals ready for market, as they sometimes do, there is very little margin in the feeding, and unless feeding stuffs are cheap and the work is very skillfully managed, a loss is almost sure to follow.

SUMMARY.

1. Leaving the root lot out of consideration, it required a greater amount of digestible dry matter in every instance, except one, for a pound of gain the second period than the first, the average for the second being 9 pounds and for the first 6.71 pounds for 1 pound of gain. The average rate of gain, too, was a little more for the first period, it being 1.60 pounds per head per day, while for the second it was 1.56 pounds.

2. Feeding for the first period was the more advantageous.

The gains were higher and they required a less quantity of dry matter per pound. The results add proof to the often repeated proposition that as the animal gains in flesh, it requires a constant increase in the quantity of food for each additional pound of gain.

3. For this single trial, feeding a grain ration with lucern during the preliminary period did not prove profitable.

4. Roots had the effect of increasing the appetite without giving proportionate additional gain. From this and previous trials it may be inferred that roots cannot be economically used in feeding, simply for the nutrients they contain, being less profitable when so fed than the ordinary dry fodders.

5. The results of three trials show that straw may be profitably used as a part ration in connection with lucern and grain. The experiment detailed herein shows, too, that open-yard feeding gives a better appetite for the straw and enables the steer to make more profitable use of it.

6. With the average Utah steer and our mild, dry winters, the best results, both in rate of gain and economic use of foods, are obtained by giving the animal the freedom of the corral and a good open shed that he may occupy at will.

7. Timothy hay made the lowest and most unprofitable gain. Its relatively higher market price than lucern debars it from profitable use in cattle feeding.

8. The average yield of the corn culture experiments and the favorable results from the feeding of shredded corn fodder indicate that corn may be safely reckoned as one of the feeder's resources in Utah.

9. In rate of gain when fed without grain, lucern stood the highest and timothy the lowest of the inside sets. The per cents were as follows: lucern 100; shredded corn fodder, 79; timothy, 77. But for the whole period corn fodder ranked 100, lucorn 92 and timothy 76.

10. The quantity of dry matter required for a pound of gain was highest for lucern and lowest for corn fodder, the three standing as follows: lucern, 100; timothy, 94; and shredded corn fodder, 71. In other words, 71 pounds of corn fodder made as much gain as 100 pounds of lucern, or 94 pounds of timothy.

11. Comparing the proportion of digestible dry matter in the different foods, they stand as follows: barley, 100; pea meal, 89; bran, 70; corn fodder, 68; lucern, 64; timothy 63; straw, 51.

12. In cost per pound of digestible dry matter, at the market prices quoted, pea meal was the highest and wheat straw the lowest; all the foods standing relatively as follows: pea meal, 100; barley, 71; bran, 64; timothy, 43; corn fodder, 33; lucern, 29; straw, 10.

Bulletin No. 54—Second Part.

DIGESTION EXPERIMENTS

WITH SHREDDED CORN-FODDER, LUCERN, TIMOTHY AND WHEAT BRAN.

JOHN A. WIDTSOE.*

WHY THE EXPERIMENTS WERE MADE.

During the winter of 1896-7, the Agricultural Department carried on steer-feeding experiments, in which Shredded Corn Fodder, Timothy, Lucern and Bran were used. In discussing the results obtained from these experiments it was necessary to know the amounts of the feeds that the animals digested. From experiments made at other Experiment Stations the digestibilities of materials similar to those used could be obtained, yet, as there was no certainty that all the conditions under which the experiments had been made were the same as those that prevailed here, it was thought that digestion coefficients obtained at the time the feeding experiments were going on, with the same material and with the same animals, would increase, materially, the value of the results.

Moreover, since comparatively few digestion experiments have been made in the arid part of America, any addition to the data gained under the peculiar climatic conditions of Utah would be interesting and of value.

THE PRINCIPLE OF DIGESTION EXPERIMENTS.

The principle underlying all digestion experiments is extremely simple. The feed to be tested is carefully sampled and analyzed. Weighed quantities are then fed to the animals and the waste weighed back and carefully sampled and analyzed. The solid excrement dropped during the experimental period is also carefully collected, sampled and tested. In this manner enough data are required to determine, with great accuracy, the

*The greater part of the analytical work reported in the following pages was done under the supervision of the Station Chemist, by Messrs. W. W. McLaughlin and John Stewart, assistant chemists.

amount of different constituents eaten by the animals, and the amount ejected undigested. The difference between the quantity eaten and the quantity dropped in the manure represents the quantity digested.

The liquid excrement shows part of the food used up within the body, and, taken in connection with the exhalations of the lungs and the skin, gives a measure of the food used to carry on the activities of the organism. For such work as is here reported, which aims only at the determination of the digestion coefficients, the urine and the waste from the lungs and skin, need not ordinarily be considered.

DETAILS OF THE WORK.

For the work reported in this bulletin special box stalls were prepared, with smooth, tightly-jointed floors, walls and mangers; and, from the top of the walls, factory cloth was stretched to the ceiling so as to prevent the entrance of foreign materials from other parts of the stable, or from stall to stall. The steers were attended day and night, and the manure was caught, as it was being dropped, on shovels and kept in large weighed vessels; and the urine, allowed to fall on the floor, was washed away immediately. Every morning and evening the animals were fed and the waste of the previous feed collected, labeled and saved. The manure of the preceding night and day was thoroughly mixed and sampled each evening.

As the experiments were carried on in winter, when the manure could be kept near the freezing temperature, there was no such trouble with fermentation as many experimenters have encountered. The feed was sampled twice, before and after the experiment; and, as this was done with the greatest care, the results are believed to be as trustworthy as if the daily rations had been sampled. The waste for the whole experimental period, seven days for each kind of material, was sampled together.

The animals used were of the common native stock of this part of the country, and no selection was employed in taking them for the work. Each set had been fed on the feed tested for at least a month before the experiment begun.

All moisture determinations were made on six samples, in order to obtain accurate results; and the fodder analyses were made in duplicates. The methods of analyses followed were

essentially those of the Association of Official Agricultural Chemists.

DEFINITIONS OF TERMS USED.

For the benefit of those unfamiliar with the technical terms of agriculture the following definitions, taken principally from Farmers' Bulletin No. 56, are given.

Water is contained in all feeding stuffs. The amount varies from eight to fifteen pounds per 100 pounds of such dry materials as hay, straw, or grain, to eighty pounds in silage and ninety pounds in some roots.

Dry Matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorine, and carbonic, sulphuric and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Fiber, sometimes called crude cellulose, is the frame work of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen Free Extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats and wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

The Digestion Coefficient of a fodder constituent means the number of parts of the constituents which is digested out of every hundred parts eaten. For instance, in one of the experiments to be reported 64,873 grams of lucern, containing 8,837 grams of protein, were fed to a steer. In the manure, 2,627

grams of the protein were recovered, showing that 6,210 grams had been digested. 6,210 grams digested out of 8,837 grams eaten equals 70.27 parts out of 100. The digestion coefficient of the protein in lucern is consequently 70.27.

The Nutritive Ratio of a fodder refers to the ratio between the digestible nitrogenous and non-nitrogenous constituents. To obtain it the per cents of digestible fiber and nitrogen free extract are added, and to the sum is added the per cent of digestible fat, multiplied by 2½. The final sum is divided by the per cent of digestible protein. The quotient is the nutritive ratio. The fat is multiplied by 2½ because it is 2½ times as valuable as an equal quantity of digestible fiber or nitrogen free extract.

DIGESTIBILITY OF SHREDDED CORN FODDER.

The corn used in this experiment was grown on the Station farm and was run through a shredder, after curing.* The material fed consisted, therefore, of the whole plant—stalks, leaves and ears. Owing to the heterogenous character of the shredded corn much difficulty was experienced in the taking of a sample that should represent, accurately, the feed given to the animals. After the expenditure of considerable time and labor, methods were devised that gave samples which agreed, though taken at different times, to within three tenths of one per cent for the average variation. Such close agreement was wholly unlooked for. The corn fodder did not differ much, in composition, from the average result of all American determinations. In the following tables all the data are given which are necessary for the determination of the digestion coefficients of the various constituents of corn fodder.

Composition of Corn Fodder Fed and Wasted, and of Manure.

	Water.	Ash.	Protein	Fat.	Fiber;	Nitrogen Free Extract.
Corn Fodder, as fed,	18.64	6.09	6.87	2.59	17.90	47.91
Corn Fodder, water-free	.....	7.49	8.44	3.18	22.00	58.89
Leavings I., water-free	.....	14.54	3.63	1.17	37.28	43.38
Manure I., water-free	.....	11.77	11.50	2.46	11.97	62.29
Leavings II., water-free	.....	13.05	3.90	1.32	41.02	40.71
Manure II., water-free.	.....	12.61	10.50	1.91	14.61	60.37

* A full description of this and the succeeding fodders is given in part I of this bulletin.

Summary of Experiment with Corn Fodder, Jan. 28 to Feb. 4. Weights in Grams.

STEER I.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extract.
Fed	48,990	3,669	4,135	1,558	10,778	28,850
Wasted	8,020	1,166	291	94	2,990	3,479
Eaten	40.970	2.503	3,844	1,464	7,788	25,371
Dropped	14,178	1.669	1,631	349	1,697	8,832
Digested	26,792	834	2,213	1,115	6,091	16,539
Per cent digested	65.39	33.32	57.57	76.16	78.21	65.19

STEER II.

Fed	59,156	4,428	4,993	1,882	13,014	34,839
Wasted	4.460	582	174	59	1.830	1,815
Eaten	54,696	3,846	4,819	1,823	11,184	33,024
Dropped	20,207	2.548	2.121	385	2,954	12,199
Digested	34,489	1,298	2.698	1,438	8 231	20,825
Per cent Digested.	63.06	33.75	55.99	78.88	73.60	63.06
Average per cent Digested	64.23	33.54	56.78	77.52	75.91	64.13

The digestibility of corn fodder has been determined by several other States. The results obtained up to June, 1895, have been collected and averaged by Prof. W. H. Jordan,* and are as follows:

Digestion Coefficients for Corn Fodder.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extract.
Average	66.00	34.00	55.00	72.00	66.00	69.00
Utah	64.23	33.50	56.78	77.52	75.91	64.10

THE DIGESTIBILITY OF LUCERN HAY.

The lucern used in this experiment was bought from farmers in Cache Valley and doubtlessly is a very good average of the lucern hay ordinarily fed by Utah farmers. The composition of lucern grown in Utah does not vary a great deal, and the variations noticed depend almost wholly upon the period at which the plants are cut. Prof. W. P. Headden has shown, in Bulletin 39 of the Colorado Station, that lucern cut at the same stage varies but slightly from year to year, under the same climatic conditions, even when the soil conditions vary somewhat. The lucern used by us was of fair quality, here and there were tufts or spots which showed imperfect curing or handling. On the whole, however, the lucern was representative.

The following tables, similar to those found under the ex-

*Exp. Sta. Record, vol VI. page 5.

periment with corn fodder, furnish a summary of the results of the work with lucern.

Composition of Lucern Fed and Wasted, and of Manure.

	Water.	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extracts.
Lucern, as fed	14.61	8.45	11.54	2.39	26.11	36.90
Lucern, water-free	.....	9.90	13.51	2.80	30.58	43.21
Leavings, I, water-free	.....	9.28	11.51	1.66	34.80	42.75
Manure, I, water-free	.....	13.99	10.01	3.26	41 97	30.77
Leavings II, water-free	.....	9.28	8.86	1.14	45 51	35.21
Manure II, water-free	.....	15.21	10.57	4.01	39.05	31.17

Summary of Experiment with Lucern, Feb. 5-11. Weights in Grams.

STEER No. I.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen, Free Exeract.
Fed	68,502	6,627	9,255	1.918	20,948	29.754
Wasted	3,629	337	418	60	1.263	1,551
Eaten	64,873	6,290	8,837	1,858	19,685	28.203
Dropped	26,221	3,666	2.627	853	11,005	8.070
Digested	38,652	2,624	6,210	1,005	8,680	20.133
Per cent Digested	59.58	41.72	70.27	54.09	44.09	71.39

STEER No. II.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen, Free Extract.
Fed	59,063	5,847	7,980	1.654	18,061	25.521
Wasted	5,469	508	485	62	2.489	1.925
Eaten	53,594	5.339	7,495	1,592	15.572	23 596
Dropped	21.043	3.205	2.224	843	8,214	6.557
Digested	32,551	2,134	5,271	749	7.358	17.039
Per cent digested	60 74	39.97	70.33	47.05	47.25	72.21
Average per cent digested	60.16	40.85	70.30	50.57	45.67	71.80

The digestibility of lucern has been determined, in this country, by two Experiment Stations. Their average results* are as follows:

Digestion Coefficients of Lucern.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extract.
Average, Colo. and N. Y.	58.00	.....	73.00	51.00	46.00	68 00
Utah	60.16	40.85	70.30	50 57	45.67	71.80

There is a characteristic difference between the corn fod-

*Compilation by W. H. Jordan, Exp. Station Record, Vol. VI, p. 5.

der and lucern. About 70 per cent of the protein of lucern are taken up by the animal and only 56.8 per cent of the protein of corn fodder. In the case of the crude fibre the conditions are reversed, for against 45.7 per cent of the fibre of lucern, 75.9 per cent of the fibre of corn fodder are digested. The fat of the corn fodder is also much more digestible than that of the lucern; which is no doubt due to the large admixture of chlorophyl with tne fat of the lucern. The nutritive ratio of lucern is much narrower than that of corn fodder, so much so indeed, that it falls within Wollf's Medium Standard for horses. For the best results, lucern should be fed with some starchy or non-nitrogenous foods.

THE DIGESTIBILITY OF TIMOTHY

The timothy used in this experiment was bought, like the lucern of the previous experiment, from the farmers of Cache Valley. It was slightly mixed with red clover, lucern, and various grasses. The admixture, however, was so small that it would have little, if any, effect, on the digestion coefficients. The hay may be looked upon as representative of the timothy grown in this section of the country.

The following tables give the details of the work.

Composition of Timothy Fed and Wasted, and of Manure.

	Water.	Ash.	Protein	Fat.	Fiber	Ntirogen Free Extract.
Timothy as fed	13.10	5.87	5.84	1.49	31.62	42.08
Timothy, water-free	.....	6.76	6.72	1.72	36.38	48.42
Leavings I, water-free	.....	7.25	5.91	1.73	40.56	44.55
Manure, I, water free	.....	11.52	9.36	2.56	34.19	42.37
Leavings, II, water-free	.....	8.02	5.00	2.23	35.03	49.72
Manure, II, Water-free.	... ..	11.52	8.93	2.44	35.07	44.01

Summary of Experiment with Timothy, Feb. 11-18. Weights in Grams.
STEER No. I.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen, Free Extract.
Fed	36,176	2,445	2,431	622	13,161	17,517
Wasted	14 612	1.059	864	253	5,927	6.509
Eaten	21,564	1,3·6	1,567	369	7.234	11.008
Dropped	8,946	1.031	837	229	3,059	3.790
Digested	12.618	355	730	140	4,175	7,218
Per cent digested	58.51	25.62	46.59	37.94	57.92	65.57

STEER No. II.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extract.
Fed	50,210	3,394	3,374	864	18,266	24,312
Wasted	3,593	288	180	80	1,259	1,786
Eaten	46,617	3,106	3,194	784	17,007	22,526
Dropped	19,917	2,294	1,779	485	6,984	7,766
Digested	26,700	812	1,415	299	10,023	13,760
Per cent digested	57.28	26.14	44.30	38.14	58.78	61.09
Average per cent digested	57.90	25.88	45.45	38.04	58.35	63.33

The digestibility of timothy has already been determined at this Station and reported by the experimenter, Prof. W. P. Cutter, in Bulletin No. 16. Prof. Cutter had for his object the determination of the relative digestibilities of green and dry timothy; Other Experiment Stations have also studied the digestibility of timothy. The results are stated in the following table.

Digestive Coefficients for Timothy.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen, Free Extract.
Average* (incl. Utah C,)	58.00	37.00	49.00	57.00	53.00	63.00
Utah (Cutter)	64.06	31.69	48.46	53.26	55.75	67.84
Utah (Widtsoe)	57.90	25.88	45.45	38.04	58.32	63.33
Average (for Utah)	60.98	28.79	46.96	45.65	57.04	65.59

*Compilation by W. H. Jordan, Exp. Sta. Record. Vol. VI. p. 5.

The present determination agrees fairly well with Prof. Cutter's; although the protein is slightly lower and the crude fibre somewhat higher. The small variation is no more than might be expected from the use of different samples in different years. The coefficient for the fat in this determination is much lower than that obtained in any other experiment. Prof. Lindsey quotes* the extremes as being 51.5 and 61.8. Our result is far below this minimum. Repeated analyses have failed, however, to change the result.

THE DIGESTIBILITY OF WHEAT BRAN AND SHORTS.†

As bran cannot be fed alone to a steer it was necessary to feed with it some fodder, the digestibility of which was known, and to obtain by indirect means the coefficient for the digestibility of bran. Bran has a narrow nutritive ratio, i. e. it is com-

*8th Ann. Report Mass. Hatch Station p. 99.

†The mixture here tested consisted of 28.5 per cent "shorts" and 71.5 per cent "bran."

paratively rich in nitrogen and it must therefore be mixed with some fodder having a wider nutritive ratio. Corn was the material chosen and was fed to the steers as nearly as possible in the ratio of one of bran to one and seven tenths of corn fodder. The bran was fed in such a way as to maintain this ratio and there was, consequently, no waste beside what came from the corn fodder.

The following tables, constructed on the same principle as the preceding, show all the data used in finding the coefficients for the ratio and for the bran.

Composition of Materials Fed and Wasted, and of Manure.

	Water.	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extract.
Corn Fodder, as fed	18.64	6.09	6.87	2.59	17.90	47.91
Corn Fodder, water-free	.. .	7.49	8.44	3.18	22.00	58.89
Bran, as fed	9.72	4.26	14.14	3.48	8.28	60.13
Bran, water-free	.....	4.72	15.66	3.86	9.17	66.59
Leavings, water-free	.....	9.71	4.18	1.25	38.75	44.86
Manure, water-free	.....	12.30	10.07	3.33	15.60	58 70

Summary of Experiment with Corn and Bran. Feb. 18–27. Weights in Grams.

STEER No. I.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen Free Extracts.
Corn fed	45.170	3,387	3,812	1 436	9,937	26,598
Corn wasted	3.102	301	130	39	1 202	1,430
Corn eaten	42.068	3,086	3,682	1,397	8,735	25,168
Bran eaten	25 515	1,204	3.996	985	2.340	16,990
Total eaten	67.583	4,290	7.678	2,382	11.075	42,158
Dropped	25 729	3.165	2,590	856	4.015	15,103
Digested	41.854	1,125	5,088	1,526	7,060	27.055
Corn Digested	27.020	1.035	2.091	1,083	6.631	16.140
Bran digested	14.834	90	2,997	443	429	10 915
Per cent ration digested	61.92	26.23	66.27	64.02	63.75	64.18
Per cent bran digested	58.14	7.50	75.75	44.98	18.33	64.25

A part of the results obtained from the second steer was lost, so that the coefficient for the dry matter only could be obtained: it was 62.23.

According to Jordan the digestibility of wheat-bran has been determined by two American Experiment Stations, with average results as stated in the following table.

Digestion Coefficients for Wheat Bran.

	Dry Matter	Ash.	Protein	Fat.	Fiber.	Nitrogen, Free Extract.
Average	61.00	.....	78.00	72.00	25.00	68.00
Utah	60.19	7.50	75.75	44.98	18.33	64.25

The digestion coefficients here reported were obtained on the assumption that the digestibility of corn fodder or any other feed is the same when fed with bran as when it is fed alone. We know that this is not the case; but in the present state of the science of stock feeding the assumption must be made when studying feeds similar to bran.

SUMMARY OF RESULTS.

The results obtained from the work just discussed are collected in the following table, in order to afford easy comparison.

Digestion Coefficients Determined in 1897 at the Utah Station.

	Dry Matter.	Ash.	Protein	Fat.	Fiber.	Nitrogen, Free Extract.
Shredded Corn Fodder	64.23	33.54	56.78	77.52	75.91	64.13
Lucern	60.16	40.85	70.30	50.57	45.67	71.80
Timothy	57.90	25.88	45.45	38.04	58.35	63.33
Wheat bran	60.19	7.50	75.75	44.98	18.33	64.25

THE AMOUNT OF DIGESTIBLE NUTRIENTS IN THE FEEDS.

The coefficients derived in the preceeding pages show the amount of a nutrient which is digested, compared with the whole amount of the nutrient eaten; but does not show how much digestible protein, or fat, or any other nutrient is found in a pound, let us say, of the fodder as actually given to the animals. By using the coefficients above found in a simple calculation it is, however, easy to determine the digestible portions of a cattle food.

As an illustration we may take the corn fodder used in this work. By referring to its composition on a previous page, it is found to contain 6.87 per cent of protein, or, in other words, 6.87 pounds of protein in 100 pounds of the fodder as fed. Now from our results we have found that of 100 pounds of protein in corn fodder only 56.78 are digested. Then, of the 6.87 pounds of protein found in 100 pounds of fodder, only 56.78 x 6.87=3.90 are digested. The per cent of digestible protein in shredded corn fodder is therefore 3.90.

In the same way the per cent of digestible fat may be found. The per cent of fat in corn fodder is 2.59, and the digestion coefficient is 77.52. Multiplying the per cent of fat by the digestion coefficient we obtain, as our per cent of digestible fat, 2.59 x77.52=2.01. The other constituents may be treated in the same way.

In the following table the feeds considered in this bulletin have been thus treated for the convenience of farmers who are in the habit of compounding rations for their stock.

The Digestible Nutrients and the Nutritive Ratios.

	P'r cent Water.	P'r cent Protein	Per cent of Non-nitrogenous Nutrients.			Nutritive Ratios.
			Fat.	Fiber.	Nitrogen, Free Extr	
Corn Fodder	18.64	3.90	2.01	13.59	30.72	1:12.6
Lucern	14.61	8.11	1.21	11.92	26.49	1:5.1
Timothy	13.10	2.65	0.57	18.45	26 65	1:17.5
Wheat-Bran	9.72	10.71	1.57	1.68	38.63	1:4.1